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(54) Method and apparatus for sealing capsules and capsules suitable for use in said method and apparatus

(57) The invention is concerned with a method of sealing a hardshell capsule having coaxial body parts which overlap when telescopically joined with each other, thereby forming a gap around a circumference of the capsule, comprising the steps of individually applying a sealing liquid including a solvent uniformly to the external edge of the gap of a capsule to be sealed to form a liquid ring around the circumference of the capsule, removing excess sealing liquid from the exterior of the capsule, drying the capsule by applying thermal energy from outside while gently tumbling and conveying the capsule on a spiral path.

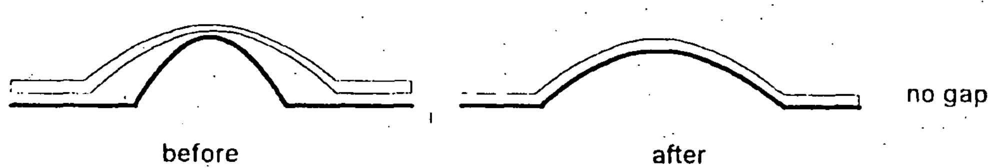

Fig. 1

EP 1 072 245 A1

Description

[0001] The present invention relates to a method and to an apparatus for sealing telescopically joined capsules with coaxial partly overlapping body parts, through subsequent application of a solvent and thermal energy. The present invention further relates to a capsule design particular suitable for such process and apparatus.

[0002] The capsules to be sealed by utilizing the present invention are preferably hard shell gelatin capsules or other capsules made from materials or their compositions which are pharmaceutically acceptable with respect to their chemical and physical properties.

[0003] The problem to be solved with respect to such capsules as compared to other dosage forms is the fact that the coaxial body parts must be well sealed in order to avoid leaking of any content to the outside or contamination thereof. Further, tampering with the content of the capsule or the capsule as such should be evident and externally visible for safety purposes and any technique of sealing the capsules must be suitable for large scale bulk production to reduce manufacturing time and costs and to reduce waste due to imperfections of the product.

[0004] EP 0 116 743 A1 and EP 0 116 744 A1 respectively disclose similar methods and devices for sealing such capsules having hard shell coaxial cap and body parts which overlap when telescopically joined. The process employed comprises the steps of dipping batches of the capsules randomly oriented in mesh baskets or oriented with their cap parts upright into a sealing fluid making capillary action within the overlap of the cap and body parts or spraying the sealing fluid or steam thereof onto the seam of the overlap, removing the sealing fluid from the surface of the capsules by an air blower, and applying thermal energy to the capsules while conveying the baskets through a dryer. Both documents disclose the use of a wide range of sealing fluids and specific temperatures and modes for the application of thermal energy, the disclosure of which is incorporated herein by reference.

[0005] EP-0 180 543 A1 also discloses a method for sealing telescopically joined capsules with coaxial body parts, through subsequent application of a sealing liquid to the overlapping region at the joint between a cap and a body, the removal of excess sealing liquid, and the application of thermal energy for drying purposes. This document particularly describes various designs of capsules suitable to be used for such process which have a ridge type structure in the cap and/or in the body for exactly coaxially positioning the cap and the body. The disclosure of this document is incorporated herein by reference, too.

[0006] The prior systems for sealing the telescopically joined capsules with coaxial body parts, through subsequent application of a solvent and thermal energy are partly imperfect as regards the quality of the seal and the controllability of the process parameters influencing the quality of the seal.

[0007] The present invention aims at providing an improved method and apparatus for sealing telescopically joined capsules with coaxial partly overlapping body parts, through subsequent application of a solvent and thermal energy and an improved capsule design particular suitable for such process and apparatus.

[0008] With respect to this object the present invention provides a method and an apparatus for sealing telescopically joined capsules with coaxial partly overlapping body parts and a capsule design as defined in the appended claims.

[0009] The present invention will now be described in more detail, by way of example, with reference to the accompanying drawings in which:

Fig. 1 shows an enlarged detail of an overlapping sealing portion of a capsule according to the present invention, and

Fig. 2 shows a schematic structure of a drying basket used in the method and apparatus of the present invention and a path of the capsules during operation thereof.

[0010] First, general enumerative description will be made on the system comprising the method and apparatus and capsule of the present invention to highlight the key features and aspects thereof. The below list is not ordered or comprehensive but does cover in brief the aspects which will differentiate the system of the invention from prior methods.

[0011] The present invention provides the following aspects:

[0012] It does not need orientated capsules which simplifies operation and increases reliability of the process.

[0013] The sealing fluid application is spatially controlled to optimize the wetted areas for good sealing, with minimum tackiness and fastest drying.

[0014] The temperature of the sealing fluid can be controlled to achieve efficient wicking and optimum dissolution rate. This implies the use of both heating and cooling systems as, for example, systems utilizing gelatin capsules require temperatures above ambient, whereas HPMC (hydroxypropylmethyl cellulose) systems work best with hot solvents and ambient temperature drying.

[0015] The volume of sealing fluid applied on the space around the gap between the body parts of the capsule, i.e. the cap and the body, is adjustable to prevent excess wetting.

[0016] The sealing fluid is applied uniformly around the capsule to get the full area seal required.

[0017] Excess sealing fluid is removed by a combination of airjets and/or aspiration.

[0018] The system is designed so that capsule size change requires a minimum change of components.

[0019] The system is designed to work with a range

of sealing fluids including, but not restricted to alcohol/water mixtures in case of gelatin capsules as described in EP 0 116 743 A1 and EP 0 116 744 A1 incorporated by reference. For capsules made out of other materials, e.g. starch, HPMC, etc., alternative solvent systems are required. The present invention provides a wide range of control for the critical sealing and drying parameters, such as temperature, solvent formulations, time, airflow, so as to enable optimum processes to be used and well controlled.

[0020] The transportation of the capsules after sealing is achieved in a fashion which minimizes contact with surfaces of the apparatus and each other to reduce the risk of sticking or cosmetic damage.

[0021] The rate of drying of the capsules is carefully controlled to ensure that the inner overlapping surfaces bond securely to each other as the solvent evaporates but the fluid does not have time to diffuse into the bulk of the capsule material.

[0022] Reliable bonding at the cap to body requires the overlapping surfaces to be in contact at conditions where the surface will weld into joint with a strength comparable to the minimum time required for the gelatin long chain molecules to intertwine. This sets the drying rate to which the system is to be adjusted.

[0023] The contact pressure between the surface to be bonded is maintained by a combination of the interference forces resulting from the precise manufacturing control of the capsules and expansion of the gelatin due to fluid absorption.

[0024] Drying of all surfaces at uniform rate is necessary to avoid distortion or poor sealing and is achieved by the air blown, capsule tumbling mechanism of the drying basket device of the present invention.

[0025] The implementation of the drying process uses an air flow with control of temperature, flow rate and humidity chosen to achieve the temperature, time, moisture profile necessary to achieve a strong bond of the capsules.

[0026] The capsules are dried in the drying basket device which provides control of transport rate whilst gently tumbling the capsules to ensure all surfaces are uniformly dried and the capsules do not stick together

[0027] The surface, material and form of the helical screw in the drying basket device is designed to ensure capsules are not retained and are minimally damaged by the contact therewith during operation.

[0028] The porosity of the structure forming the drying basket device is designed to ensure low air resistance and uniform airflow over the capsules.

[0029] Two or mare parallel high air jets adjustable in width and location are directed up along the line of the lowest point of the drying basket device with a speed sufficient to lift any capsules tending to adhere to the surface.

[0030] The control of the rotational speed of the drying basket device allows control of the time of drying as the axial translation speed is a function of rotational speed.

[0031] Control of drying air parameters is achieved using servo control systems to maintain uniform conditions even in the event of external changes.

[0032] Implementation of the total sealing system is in a self contained unit of small footprint making it compatible with installation in the environment of a capsule filling line.

[0033] The system of the present invention thus enables sealing of liquid filled capsules immediately after filling at a rate compatible with conventional capsule filling lines.

[0034] As the apparatus of the present invention can be fed from a standard hopper there is no requirement for closely coupling the outfeed of the filler to the infeed of the sealing apparatus of the invention. This allows buffer volumes to be used to smooth production flow for short stoppages of either the filler or the sealing apparatus.

[0035] The basic improvement of the method and apparatus of the present invention over the prior art sealing systems reside in the control of the gap geometry of the body parts of the capsules to ensure full uniform wicking along the whole overlapping length and the design of the drying process or of the suitable devices for this step which removes the solvent in a way that causes the gap to close completely and the body parts to stick together perfectly.

CAPSULE DESIGN

[0036] The capsule design most suited for use in the sealing system of the present invention consists of two halves which are concentrically overlapped partly when telescopingly joined together. The fundamental method by which the seal is made between the two halves is for a solvent or sealing liquid to be introduced into the gap between the two halves at the overlapping region such that as the solvent evaporates the inner surfaces are drawn into contact whilst soft and fused together.

[0037] To achieve a good seal with this method it is necessary that a sealing liquid, i.e. a solvent must fill all of the gap between the surfaces that are to bond together. For capsules this is the full length of the overlapping region between cap and body. The two surfaces to be bonded together have to react to the solvent such that the inner surfaces are soft and tacky at the time they are brought together to form the bond. This may be achieved by controlling the temperature and time that the solvent is in the gap before it evaporates to bring the surfaces into contact. Finally, the action of removing the solvent needs to apply a force to the two surfaces to be bonded to hold them together as the bond forms.

[0038] The present invention addresses these issues in the design of the capsule, the application of the solvent and the mechanism of drying.

[0039] To support the uniform filling of solvent into the gap the capsule is designed to have features which uniformly separate both the surfaces to a predetermined

distance whilst the solvent is introduced into the gap. If the gap is wide in some places and non existent in others then the distribution of the solvent across the area will vary leading to poor sealing at some points around the capsule. The gap is allowed to close completely as the solvent is removed and the bond forms. The closing forces are of limited strength so that any resistance to the surfaces being pulled together may reduce the bond strength. Also, as the product inside the capsule is not a solvent for the capsule material and if it penetrates into the gap then it will block the action of the sealing solvent, the capsule design is preferably such that contamination of the gap by the products inside the capsule is prevented.

[0040] An important aspect of the invention is the precision with which all these requirements are achieved by the tolerances of the capsule manufacture and the control of the parameters such as temperature, time, solvent volumes, solvent location, drying conditions with the sealing system.

[0041] There are various designs of the capsule in order to achieve the required gap control whilst maintaining all the other requirements of capsules such as, appearance, manufacturability, ease of swallowing, etc.. A number of suitable designs have been incorporated by reference to the disclosure of EP-0 180 543 A1. One preferred implementation uses a symmetric arrangement of at least 3 bumps in the body which can optionally interlock into dimples or a groove in the cap. These features provide axial positioning and hold the cap concentric to the body so providing the uniform gap. The exact implementation could include one or more variations such as axial raised rings and matching grooves, a uniformly roughened surface on one or more of the faces, a multiplicity of bumps and dimples, a plurality of circumferential grooves and dimples, and a spiral ridge and dimples.

[0042] The gap size is chosen so that volume of solvent wicked-in is sufficient to perfuse the inner surface of the gap sufficiently to modify the surface to become soft and tacky to allow them to bond when pressed together. This volume will be dependent upon the material, the temperature and the force applied to bond the surfaces. Typically the gap is within the range 0.05 mm to 0.5 mm. Typically the volume of solvent that is required to initially fill the gap is between 5 µl and 20 µl.

[0043] In order to allow the gap to close as the solvent is removed some allowance must be made for the movement. This may be achieved by a number of designs the common feature being that the designs have no features extending into the gap which remain rigid enough to prevent the gap from closing. Where spacing features are employed then a design of spacing features which, as it softens with the action of the solvent, distorts to permit the required motion is particularly advantageous. An example of such a feature is shown in figure 1.

[0044] The geometry of the spacing feature shown in this figure is such that there is surrounding space for the material of the bump to flow into as the gap closes. Corresponding designs for the other implementations are possible provided the principle of allowing the deformation of the shapes to be accommodated for minimum flow is followed.

[0045] Preventing the product infusing into the gap region whilst the solvent is present requires providing a seal at the end of the gap exposed to the interior region of the capsule, providing a positive pressure from outside of the capsules to inside to prevent flow of product into the gap, and/or immobilizing the product to prevent it flowing into the narrow gap.

[0046] The preferred embodiment of a capsule to be used in the method and apparatus of the invention is to seal the top of the gap by appropriate design of the locking features.

SOLVENT APPLICATION

[0047] The second requirement of sealing is to modify the interior surfaces of the gap between cap and body so that they are soft and tacky as they are drawn together. As described previously this requires control of the type and amount of sealing liquid or solvent and the temperature thereof. The present invention provides a mechanism for implementing the concept with a wide range of solvents, of the type described in previous patent applications related to this field or incorporated by reference. The use of a capsule which has a well controlled gap sealed off from the contents facilitates the impregnation of the inner surfaces with the required volume of solvent.

[0048] In the preferred embodiment of the invention the solvent is presented to the external edge of the gap uniformly around the circumference. The surface tension effects draw the solvent from the outside uniformly up into the gap provided that the gap spacing is uniform. To prevent softening of the external surfaces any excess solvent is removed as quickly as possible.

[0049] There are various techniques for applying the solvent to the gap including a spray emanating from several points around the capsule directed towards the external edge of the gap and lasting for a period designed to deliver the appropriate volume of solvent on the capsule, an implementation as above, where the spray is replaced by an array of piezo or thermal ink-jet heads dispensing the appropriate solvent, an arrangement of sponges, brushes, wicks, etc. which transfer solvent by contact to the required position, and jets of solvent vapor directed to the open end of the gap to condense the vapor directly on to the capsule.

[0050] In addition to dispensing the required volume uniformly around the gap entrance, the system must remove any excess liquid solvent on the surface of the capsule before it softens the material. This can be achieved by various means, including aspiration to suck away liquid, air jets to blow liquid off the surface, wicking to absorb liquid on contact, centrifuged force to spin off

excess liquid, shaking to throw off excess liquid or combinations of these measures.

[0051] The preferred embodiment of sealing apparatus of the invention makes use of 3 spray nozzles spaced 120° around the circumference directed at the external opening of the overlap gap with excess liquid being removed by a combination of airjets and aspiration. In addition to the precise control of the volume and location to which the solvent is applied, the temperature of the capsule, solvent and the atmosphere need to be held within defined limits. The level of control required depends upon the materials and variability of the environment. The apparatus is provided with a suitable temperature control system to provide the appropriate conditions for operation in a wide range of environments.

SOLVENT REMOVAL

[0052] The third requirement is to remove the solvent in the gap in a manner which generates a force to hold the surfaces together as they dry. The ultimate method of solvent removal is as a vapor, its transport being achieved by entrapment in an airstream at the appropriate temperature. Transport of the solvent from the gap to the air takes place by several mechanisms like flow along the gap to support evaporation from the exposed liquid surface, diffusion through the capsule cap material to evaporate from the outer surface, diffusion through the capsule body material and mixing with or absorption into the contents fluid, and diffusion into and binding to the capsule material of both cap and body.

[0053] All of these methods can participate in the drying process in a way which removes the solvent without introducing air. As this happens the atmospheric pressure forces the cap and body surfaces together with a pressure up to 100,000 Newton per square meter.

[0054] All of these transport mechanisms speed up if the temperature is increased. However, excessive temperature can lead to situations which prevent a good bond forming, for example vapor bubbles forming and distorting the surface, excess flow rates in the liquid allowing air entrapment, internal pressure rise displacing air from inside the capsule through the gap, thermal stresses distorting the capsule, or excessive drying of the outer surfaces increasing the stiffness to prevent closure.

[0055] The present invention optimizes the temperature and airflow to achieve capsule drying at a commercially acceptable rate without degrading the quality of the seal by any of the mechanisms described above.

[0056] In the following a preferred embodiment of the apparatus for sealing the capsules will be described in detail.

[0057] In one preferred embodiment all of the requirements and devices for effective sealing are implemented in a self contained machine.

[0058] This embodiment has an input hopper which can receive capsules from any source at any rate. Typically capsules would be fed using a conveyor or an air transport system.

[0059] The capsules at this stage are mechanically held closed by the features in the capsule caps and bodies and for a partial seal sufficient to prevent the content of the capsules from leaking out during mechanical transportation with the sealing system.

[0060] The hopper is designed to feed capsules in a number of entry tubes which will transport the capsules into the sealing apparatus. Capsules are gravity fed from the hopper into the tubes with the movement being assisted by a reciprocating vertical motion of the input tubes over a distance of between 0.5 cm and 5.0 cm and at a rate designed to ensure smooth, blockage free motion.

[0061] An optional capsule orientation station can be inserted between the hopper and the feed tubes to ensure that the capsules enter the tubes with a predetermined orientation. This function is not necessary for efficient sealing, but may be used in combination with a reduced spray pattern head designed to minimize the volume of solvent utilized or to limit the softening of the capsule outer surfaces.

[0062] In one embodiment six input tubes are used and this number will be taken as the example for subsequent descriptions, however implementations with any number of parallel paths may be used to meet the required throughput.

[0063] The capsules in the input tubes are prevented from moving by mechanical latches whose opening cycles are controlled by the system controller. In order to implement the sealing function a large number of actions must be undertaken with precision timing and relationships. In the preferred embodiment all of these actions are controlled using a Programmable Logic Controller (PLC) so that the sequences and timings can be adjusted to meet the requirements of a range of solvent systems to suit different capsule designs and materials. It is a feature of the present invention that the PLC enables a single machine to be able to work with different processes, materials and capsule sizes.

[0064] The actions demanded by the controller may be achieved using combinations of a range of actuators, including, but not limited to solenoids, pneumatic valves and cylinders, motors, and cams.

[0065] At the start of the sealing cycle the PLC releases the latch restraining the capsules and allows the leading capsule in each tube to fall into the location at which the sealing will take place. This point is known as the spray bar. The spray bar has a mechanism to hold the capsules in place whilst solvent is sprayed onto the middle section of the capsules so that it is in uniform contact all around the end of the overlap of the cap over the body. This is achieved by surrounding each capsule with an annular manifold in which are located a number of small holes. These holes are positioned and angled such that liquid emanating from them will reach the capsules at the desired location. Where the capsules are

not orientated then the area on the capsule encountered by the solvent must be such that whatever orientation the capsule is in the end of the gap is covered in solvent. Where capsules are orientated, the area covered by the solvent can be reduced to just that area around the end of the gap. In order to achieve the desired coverage the holes are angled, typically at 45° and uniformly spaced around the capsule.

[0066] Each spray bar has holes for each of the capsule feed tubes, typically 6, and liquid is fed to the spray nozzles by a manifold within the spray bar. The liquid is forced from the nozzles onto the capsules by pressurizing it by connecting it to a permanently pressurized supply via a control valve. The form and volume of solvent delivered to the capsule is controlled by the EFD valve controller by adjusting the time the valve is open and the pressure of the supply. To prevent solvent delivery when not required, additional interlock valves may be included in the delivery line.

[0067] The system typically delivers liquid volumes in the range 20 µl to 200 µl to each capsule, suing pressure in the range 1 bar gauge to 5 bar gauge and spray times between 0.1 seconds and 1.0 seconds, depending upon the capsule size and material.

[0068] The velocity and volume of the flow of solvent into the annular space around the capsule can be adjusted to achieve the desired form to ensure uniform penetration of the solvent into the gap between cap and body. This includes conditions like high velocity to form an aerosol mist, medium velocity to form a liquid jet on to the surface, and low velocity to form an liquid ring which expands to just touch the capsule.

[0069] The system supplies more solvent to the capsule than can be taken up into the gap in order to ensure that all of the area is well supplied by the solvent. The excess solution is removed from around the capsule by vacuum suction and/or air jets. This action is also controlled by the PLC and the air/solvent is removed from the area around each capsule via an additional array of holes located adjacent to the spray nozzles. These holes are interconnected by a second manifold in the spray bar and hence connected to a vacuum pump and collection vessel in which the solvent vapor may condense and liquid trap.

[0070] At the completion of the solvent spray and excess removal, the capsules have the solvent in place in the gap but are still tacky from the action of the solvent on the exterior surfaces. The capsules must then be dried under carefully controlled conditions so that the seal is correctly formed and capsules do not stick together or become cosmetically damaged by sticking to other surfaces.

[0071] The method by which this is achieved in the preferred embodiment is to rotate the spray bar away from the feed tubes to align the capsules with entry ports into a drying basket. This is achieved by mounting the spray bars within a cylinder which can rotate. To remove the capsules from the spray bar the cylinder is rotated 120° and the capsules are ejected by a combination of push rods and air jets. The capsules fall down individual feed tubes angled at 60° to the vertical into one end of a drying basket.

[0072] To maintain a high throughput the cylinder on which the spray bars are mounted has fixings for 3 spray bars at 120°-intervals. This rotation to eject brings a new spring bar under the feed tubes ready for the start of the next cycle.

[0073] An additional feature permits the spray bar cylinder to rotate in the opposite direction, when directed by the PLC and for the capsules to be ejected into a separate shute which does not feed into the cylinder but into a separate outlet. This enables capsules to be removed from the machine after sealing, but before drying in order for diagnostic or process measurements to be undertaken.

[0074] In order for the machine to operate with capsules of different sizes but to maintain precise control of both the capsule feeding and the sealing operation some hardware changes need to be undertaken to accommodate a change in capsule size. The preferred embodiment limits these changes to a small number of easy to access items, such as the feed tube assembly, the spray bars, and the output sieve.

[0075] In addition, to ensure that the machine is operating correctly a number of sensors may be employed to ensure that capsules and fluids are available and have been transported correctly. These include an optical sensor at the input hopper to determine that capsules are available, fiber optic sensors in the tubes between the spray bars and the drying cylinder, pressure and vacuum sensors at the appropriate locations, and flow sensors.

[0076] The basket into which the capsules are ejected after filling comprises a tubular open mesh arrangement with internal spiral guides. The cylinder is rotated slowly such that the internal spiral causes capsules which fall onto it from the sides, as they are lifted up by the rotation, to move along the axis of the cylinder. In this fashion the capsules gently tumble around the cylinder following a spiral path of the internal spiral guide(s).

DRYING BASKET FUNCTIONS

[0077] The conditions under which capsules are dried after solvent has been introduced into the gap is critical to the achievement of a good seal. The key functions that need to be achieved in drying are:

- capsules are transported through the drying zone into a bulk storage container;
- the time capsules are in the drying zone is controlled to ensure that the capsules are sufficiently dry when entering the bulk storage that they will not stick together;
- air flows all over the capsules to achieve fast uniform drying;

- capsule to capsule contact is minimized to prevent them sticking together;
- capsule to basket contact is minimized to prevent sticking to the walls; and
- mechanical impact of the capsules is minimized to prevent damage.

[0078] The drying basket device preferably has a design which comprises a cylindrical structure predominantly fabricated from a stainless steel mesh. The material inside which is preferably a double spiral guide also is of stainless steel material.

[0079] The dimensions of the cylinder are preferably a length between 600 and 1,000 mm and a diameter between 100 mm and 200 mm with a length of 800 mm and a diameter of 160 mm being a preferred embodiment. The ratio of diameter to length is chosen to control the mechanical performance aspects, the length is a function of the duration required in the drying zone and the diameter is a function of the quantity of capsules to be handled.

[0080] In this implementation with the dimensions stated above the length is chosen to produce a capsule residence time in the drying basket of between 10 seconds and 100 seconds.

[0081] The cylindrical drying basket is orientated with its axis horizontal. In the preferred embodiment, the basket is constrained by rollers to allow it to rotate freely about the horizontal axis. The rollers may be fabricated to provide sufficient function to enable one of the rollers to be driven to cause the drying basket to rotate or the basket may be driven directly by a coupling at one end. The method of support and rotational drive must provide free airflow throughout the basket and be compatible with the requirements for cleaning and maintaining cleanliness.

[0082] In one embodiment the internal double spiral has the function of causing the capsule to tumble in one axial direction as the basket is rotated. The pitch and form of the spiral are critical to ensuring that all capsules are transported axially at the same rate. In this embodiment the spiral is fabricated from vanes spanning from a central shaft to the mesh of the cylinder. Each vane consists of two arms diametrically opposed spanning from the central shaft to the wire mesh of the cylinder. Each vane is mounted onto the shaft rotated with respect to its neighbors by a fixed angle. This angle is typically 12 degrees. The vanes are stamped from stainless steel sheet of typically 0.75 mm thickness and may optionally be PTFE coated to ensure low surface energy. The attachment of the vanes to the shaft and cylinder is accomplished by mechanical fixtures incorporated in their design. To facilitate this the shaft has circular grooves to accommodate the vanes at a spacing chosen to provide the desired spiral pitch. This pitch typically is 5.993 mm with 118 vanes producing a twin spiral structure with a spiral pitch of 179.8 mm. The shaft has diametrically opposing flats and the vanes have a corresponding profile to their central hole so that the vanes can be slid onto the shaft and locked onto the shaft at the desired groove by rotation. The attachment of the vanes to the cylinder is accomplished by grooves on the outer profile of the vanes that match to axial wires attached to the inside of the cylindrical mesh. In a typical embodiment 30 wires are used at 12 degree separation to match the vane arrangement. The assembly of the vanes into the basket is accomplished by sliding the vanes onto the shaft and rotating until they lock into place. The mesh of the outer cylinder is constructed to combine the functions of containing the capsules and providing the attachment fixtures for the vanes whilst maximising the open area to permit good air flow. To achieve this 134 separate rings of 0.16 mm diameter stainless steel wire are welded around 30 longitudinal wires of 0.2 mm diameter of stainless steel arranged at 121 increments around the circle. The longitudinal wires are inside the circumferential wires so that they act as attachment features for the vanes.

[0083] An alternative embodiment utilizes separate baskets constructed out of separate sections to allow for ease of removal. In this embodiment a 3 cm spiral construction is employed such that each spiral has a pitch of 240 mm and the basket has an internal diameter of 185 mm. The basket outer and spiral arms are fabricated from flat stampings each with the three arms formed in them and with a castellated rim such that when stacked together with a 6° offset, around a central shaft, the layers are spaced approximately 4 mm apart by the castellations and form an internal spiral with the required pitch. Known features interlock the sections together to enable the drive from one end to rotate all sections.

[0084] The construction of the drying basket in the embodiments described previously are examples of means of achieving the required transport conditions as capsules pass through the drying zones. The concept can also be achieved using a variety of designs and construction techniques. This includes, but are not limited to rectangular section baskets with flat angled baffles arranged so that as the basket rotates the capsules travel up the basket in one direction as shown in Figure 2.

[0085] The rectangular section can reduce the manufacturing cost significantly.

[0086] Further alternatives are a conveyor belt system where the conveyor belt has an open mesh structure to permit air to circulate around the capsules, wherein vibration or air jet can be optionally used to keep the capsules from sticking together or to the belt; or a contra flow drop tube in which warm air is fed into the bottom of a vertical tube at a velocity adjusted so that the weight of the capsules was just larger than the aerodynamic drag of the upward airstream. The downward velocity of the capsules can therefore be adjusted by adjusting the air velocity resulting in a transit time sufficient to dry off the excess fluid.

[0087] In a further preferred embodiment of the cylindrical drying basket device the central feature has 3

arms forming 3 interwoven spirals angled such that the spiral makes between 2 and 4 turns along the length of the drying basket.

[0088] The open mesh nature of both the outer cylinder and spiral arms allows air flowing through the drying basket to mix freely with the capsules.

[0089] To contain the basket it is housed in a surrounding solid walled container with vents for air to come in and leave. Air enters by way of two or more axial slits at the base of the basket. The slits are sized to ensure that entering air has a high velocity such that it is sufficient to lift the capsules away from the inner surface of the basket to enhance the tumbling action in ensuring that capsules neither stick to the walls nor each other. Air leaves the chamber via ports located at the opposite end from the capsule feed.

[0090] The air fed to the drying basket comes from a compressor unit capable of supplying large volumes of air at high velocity. To condition the air to the desired temperature heating or cooling heat exchangers are mounted between the compressor and the slit entry point. Air entering the compressor from the room is raised in temperature by the compression and so without additional conditioning will enter the dryer at between ambient and 30°C above ambient. By heating or cooling the range can be controlled to within the range 5°C to 80°C. The cooling heat exchanger is preferably an air-water system of similar form to that used on cars. The exhaust from the drying basket is taken by an additional high volume air pump which directs the air and solvent vapor along duct work away from the machine.

[0091] The waste air can then be vented either into the room, into the external air via ducts and chimney, or into a condenser/scrubber to remove the solvent and condition the waste air for release.

[0092] The choice of extract system depends upon the site of operation and the solvent employed.

[0093] The use of bulk supply and extract air pumps enables the pressure in the basket to be adjusted. Where solvent release into the surrounding air is to be avoided, it is important that at all locations within the dryer the pressure is less than the room pressure. The PLC can control the motors driving both pumps and hence can adjust both the pressure and flow independently.

[0094] The action of the spiral in the drying basket means that the residence time for a capsule in the drying basket is controlled simply by the rotation speed. As a capsules reach the end of the basket they fall into a sieve and drop into a storage Container or onto a transport mechanism.

[0095] Where the solvent being used should not be released into the room air additional features may be included with the system to ensure all of the solvent is removed by the purging air. These include guard shields around the spray bar cylinder assembly which form a substantially closed volume connected to the exhaust air pump to ensure any vapor released in the area is removed, a transparent guard shield to fit in place of the feed tube assembly to enable the operator to view the spray bars having solvent dumped to them, before commencing a sealing run, as a visual check to their functioning, pressure balancing the airflows to ensure that all of the volumes containing solvent are held below atmospheric pressure, an airflow arrangement on the outlet to enable capsules to exit without loss of solvent vapor, in extreme cases the capsules leaving the dryer may be housed in a sealed container through which air is blown to waste to remove any residual solvent vapor, control interlocks to prevent access to the liquid fed parts o the machine for a period after spraying which allows the airflow to remove an residual solvent vapor, and/or selection of all materials in contact with the liquid or vapor of the solvent to ensure that there is no long term degradation.

Claims

1. A method of sealing a hardshell capsule having coaxial body parts which overlap when telescopically joined with each other, thereby forming a gap around a circumference of the capsule, comprising the steps of:

   individually applying a sealing liquid including a solvent uniformly to the external edge of the gap of a capsule to be sealed to form a liquid ring around the circumference of the capsule,
   removing excess sealing liquid from the exterior of the capsule,
   drying the capsule by applying thermal energy from outside while gently tumbling and conveying the capsule on a spiral path.

2. The method of claim 1, wherein the excess sealing liquid is removed by a combination of air jets and aspiration.

3. The method of claim 1 or 2, wherein the flow velocity during application of the sealing liquid is controlled such that the liquid ring is formed which expands to just touch the capsule.

4. An apparatus for sealing a hardshell capsule having coaxial body parts which overlap when telescopically joined with each other, thereby forming a gap around a circumference of the capsule, comprising:

   means for individually applying a sealing liquid including a solvent uniformly to the external edge of the gap of a capsule to be sealed to form a liquid ring around the circumference of the capsule,
   means for removing excess sealing liquid from the exterior of the capsule,
   means for drying the capsule by applying ther-

mal energy from outside while gently tumbling and conveying the capsule on a spiral path.

5. The apparatus of claim 4, wherein said means for individually applying a sealing liquid comprise a plurality of spray nozzles uniformly spaced around the circumference of the capsule and directed at the external opening of the overlap gap and means for controlling the temperature of the sealing liquid, of the capsule and of the atmosphere at the gap.

6. The apparatus of claim 4 or 5, wherein said means for drying the capsule comprises a rotatable cylindrical drying basket device with an internal vane arrangement extending along the axis of the cylinder and arranged such that the capsule tumble and are conveyed on a spiral path upon rotation of the drying basket device.

7. The apparatus of claim 6, wherein said cylindrical drying basket device is surrounded by a solid walled container with air vents and means are provided to feed conditioned air at large volumes at high velocity into the drying basket device.

8. The apparatus of claim 6 or 7, wherein said drying basket device has a rectangular cross section and flat angled baffles as the internal vane arrangement.

9. A capsule having hardshell coaxial body parts which overlap when telescopically joined with each other to be sealed with the action of a solvent applied to the overlapping region, wherein spacing features are provided so as to provide a (uniform) gap in the overlapping region, said spacing features being structured such that they soften with the action of the solvent so that the gap is thereby closed.

10. The capsule of claim 9, wherein a seal is provided at the end of the gap exposed to the interior region of the capsule to prevent a product filled into the interior region from flowing into said gap.

11. The capsule of claim 9 or 10, wherein a product filled into the interior region is immobilized to prevent it flowing into said gap.

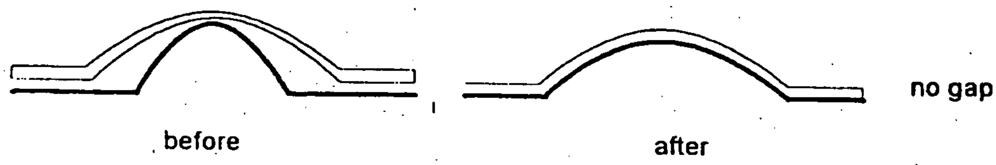

Fig. 1

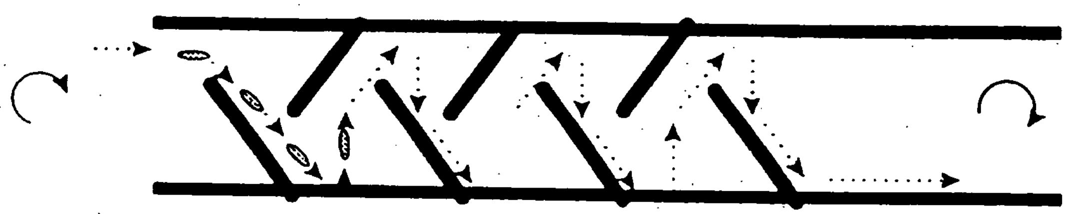

Fig. 2

European Patent Office

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	10 January 2000	Baert, F

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X : particularly relevant if taken alone
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